

Monitoring of phenolic compounds and surfactants in water of Ganga Canal, Haridwar (India)

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Abstract The Ganga Canal emerging out from Ganga River has great ritual importance among pilgrims and tourists at Haridwar, Uttarakhand, India. The Canal is being polluted due to mass bathing, washing, disposal of sewage, industrial waste and these human activities are deteriorating its water quality. To determine the impact of these activities, Ganga Canal water quality at five sites between Haridwar and Roorkee namely Pantdweep, Har Ki Pauri, Singhdwar, Piran Kaliyar and Old Bridge, Roorkee has been analyzed for organic pollutants phenolic compounds and surfactants, which have rarely been assessed and reported so far. The results of analysis show that phenolic compounds are not present in water samples of selected five sites during bi-monthly monitoring from January 2012 to November 2012. The Har Ki Pauri, Singhdwar, Piran Kaliyar and Old Bridge, Roorkee sites have been detected with surfactant concentrations (1.18, 1.63, 3.2 and 2.5 mg/l) more than permissible limit (1.00 mg/l). Also at most of the sites, surfactants' concentration crossed the desirable limit of BIS during the period of analysis. This distribution of surfactants in water has potential risk for skin diseases and cancer and requires regular monitoring with appropriate measures.

Keywords Ganga Canal · Haridwar · Water quality · Phenolic compounds · Surfactants

Introduction

The Ganga Canal originates from Haridwar and irrigates the Doab area falling between Ganga and Yamuna rivers, covering an fertile agricultural area of about 9,000 km² of ten districts of Uttarakhand and Uttar Pradesh states of India. Besides irrigation, Canal water has been used for community water supply, ritual bathing, and disposal of sewage and industrial effluents (Chauhan and Singh 2010; Deepali and Namita 2012; Kulshrestha and Sharma 2006; Mishra et al. 2009; Semwal and Akolkar 2006).

Ganga Canal water is subjected to major religious activities at Haridwar, Uttarakhand (India). Millions of devotees assemble during the auspicious occasions round the year and take a dip in the holiest Canal of Ganga River of India at Pantdweep and Hari Ki Pauri i.e. near the origin of Ganga Canal. Moreover, Haridwar is also known for two industrial estates namely Bharat Heavy Electrical Limited (BHEL) and SIDCUL, which have more than 500 companies. Sewage and municipal waste of Rishikesh and Haridwar as well as effluents of industrial units of BHEL and SIDCUL, Haridwar get mixed into the Ganga Canal water (Kaushik et al. 2012). Over the years, the Ganga Canal has become the channel of transport of industrial effluents and wastewater of the nearby residential areas and causes threat to society as a large portion of it eventually reaches the Canal water through natural drainage system. Organic pollutants namely surfactants and phenolic compounds are important pollutants which are likely to enter in environmental water through mass bathing/washing and incomplete disposal of industrial effluents, respectively,

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and can pollute the Canal water quality. The concentration of these compounds greater than permissible limits can lead to chronic toxicity and may alter the properties of water of Ganga Canal. Thus, increase in the pollution load of soil system and ground water aquifers may ultimately affect the health of the users as well as local population (Hanif et al. 2012; Shinde 2006). The composite effluents of different industries have contributed significantly for the degradation of surface water and soil quality of adjoining areas of industrial zone at Haridwar (Kar et al. 2008; Kumar and Bharti 2012). Moreover, the excessive presence of both the pollutants in water may lead to blood toxicity, eyes and skin irritation, reproductive interferences, paralysis of central nervous system, severe drop in body temperature and even cause cancer in humans and chronic and sub lethal activities to aquatic organisms (Davi and Gnudi 1999; Etxebarria et al. 2012; Exner and Farber 2006; Lewis 1991; Li et al. 2009).

In spite of a number of available reports, no regular monitoring data are available for water quality characteristics especially phenolic compounds and surfactants as per Bureau of Indian Standards (BIS 1991) about water quality of Ganga Canal at various sites falling under the industrial area zones of Haridwar and nearby city Roorkee. The present study was therefore, conducted to determine the concentration of these two organic pollutants in surface water quality of Ganga Canal which is being used for drinking and other domestic activities.

Materials and methods

Study area

Water samples were collected bimonthly from January 2012 to November 2012 from five main sampling sites of Ganga Canal from Haridwar to Roorkee, Uttarakhand (India). GPS co-ordinates, which were collected from each site using GPS system (Garmin, 76 CSX) are given in Table 1.

Sample collection and analytical methods

Collection, preservation and transportation of water samples to the laboratory and analysis were executed as per standard methods. The water samples for phenolic compounds and surfactants analysis were collected in acid-leached Tarson bottles. All samples were stored in insulator cooler containing ice, brought to the laboratory, and kept at 4 °C until processing and analysis (Eaton et al. 2005; Kazi et al. 2009). The phenolic compounds were determined using chloroform extraction method (APHA, 5530-C) and surfactants by methylene blue active substance (APHA, 5440-C) using UV–VIS spectrophotometer (Model—Pharo 300). A concentration of 0.001 mg/l has been recommended as desirable limit and 0.002 mg/l as the permissible limit for phenolic compound and concentration of 0.20 mg/l as desirable limit and 1.0 mg/l as permissible limit for surfactants in drinking water as per BIS: 10500 (1991).

Results and discussion

The results of analysis of phenolic compounds and surfactants observed at different sites of Ganga Canal, during January to November 2012 (bimonthly) are summarized in Table 2. During January 2012, the analytical results of water samples of Ganga Canal showed that out of all the sites, only SN4 site had the surfactant value of 0.50 mg/l, whereas, phenolic compounds were not found at any of the site studied. However, during March 2012 (when tourists start coming to Haridwar) surfactants were present in appreciable quantities ranging from 0.38 to 0.64 mg/l at all the five sites of Ganga Canal from Haridwar to Roorkee, whereas phenolic compounds were again found absent at all the sites.

Similar to the above findings, the results of the May and July 2012, which are the peak pilgrims and tourists seasons at Haridwar, showed that all the sites have relatively higher amount of surfactants in water samples. The maximum value of surfactants' concentration was found 1.18 mg/l in

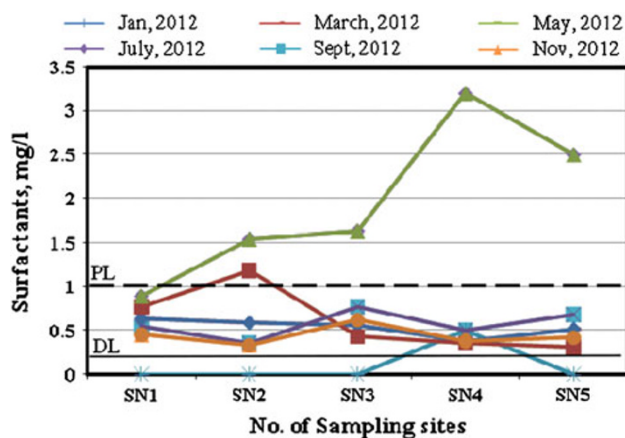
Table 1 GPS location of sampling sites

Site code	Name of sampling site	Latitude	Longitude	Elevation (MSL in m)
SN1	Pantdweep Ghat, Haridwar	29°57'33.8"N	78°10'25.3"E	282
SN2	Har Ki Pauri Ghat, Haridwar	29°57'25.0"N	78°10'15.9"E	283
SN3	Singhdwar Ghat, Haridwar	29°55'39.2"N	78°07'58.8"E	275
SN4	New Bridge Ghat, Piran Kaliyar, Roorkee	29°55'21.4"N	77°56'15.2"E	262
SN5	Old Bridge Ghat, Roorkee	29°52'29.2"N	77°53'21.4"E	260

Table 2 Concentration of phenolic compounds and surfactants in Ganga Canal water

Site codes	Phenolic compounds (mg/l)						Surfactants (mg/l)					
	DL: 0.001 mg/l; PL: 0.002 mg/l						DL: 0.20 mg/l; PL: 1.00 mg/l					
	January	March	May	July	September	November	January	March	May	July	September	November
SN1	ND	ND	ND	ND	ND	ND	ND	0.64	0.77	0.71	0.54	0.45
SN2	ND	ND	ND	ND	ND	ND	ND	0.59	1.18	0.45	0.35	0.33
SN3	ND	ND	ND	ND	ND	ND	ND	0.56	0.43	1.63	0.77	0.62
SN4	ND	ND	ND	ND	ND	ND	0.50	0.38	0.35	3.20	0.50	0.38
SN5	ND	ND	ND	ND	ND	ND	ND	0.52	0.31	2.50	0.68	0.42

DL desirable limit, PL permissible limit, ND not detected

**Fig. 1** Bi-monthly variation in surfactants' concentration at all five sites of Ganga Canal

May, 2012 at SN2 and 3.20 mg/l in July, 2012 at SN4. The lowest concentration was found 0.31 and 0.45 mg/l at SN5 and SN2, respectively, in May and July 2012 i.e. more than desirable limit of 0.20 mg/l as per BIS.

In September and November 2012, no presence of phenolic compounds was found at all the sites. Slightly lower concentration of surfactants were found during these 2 months as compared with the results of July 2012 but these concentrations ranging from 0.35 to 0.77 mg/l and 0.33 to 0.62 mg/l, respectively, in September and November 2012 were still found higher than desirable limit of BIS. The maximum concentrations of 0.77 and 0.62 mg/l were recorded at SN3 site during September and November 2012, respectively.

The above bi-monthly monitoring study, carried out for a period of 9 months, clearly shows that Ganga Canal water is not at all polluted by phenolic compounds at all the five sampling sites selected for analysis. However, the effects of mass bathing and washing are clearly visible due to the presence of surfactants at all the five sites during March to November. In the month of January, the surfactants were not detected in the study sites due to less anthropogenic activities as well as not a peak season for

tourist activities except at Piran Kaliyar site (SN4), as the site is continuously used for washing center of clothes in addition to bathing. Figure 1 clearly demonstrate the highest concentration (3.20 mg/l) of surfactants' obtained at SN4 site (Piran Kaliyar, Roorkee) and minimum concentration (0.31 mg/ml) at SN5 site (Old Bridge, Roorkee), whereas phenolic compounds are found within prescribed limits at all studied sites. The present study also find support from reports published elsewhere (Hanif et al. 2012; Murakami and Takada 2008; Mungray and Kumar 2008), which attribute presence of surfactants' in Canal water due to various anthropogenic activities caused by human along the stretch of Ganga Canal in Haridwar.

Conclusions

The water quality is expected to be deteriorated through phenolic compounds and surfactants from nearby BHEL and SIDICUL industrial areas and also through washing of clothes as well as mass bathing activities along the stretch of Ganga Canal at different sites from Pantdweep, Haridwar to Old Bridge, Roorkee. Through the present monitoring study of phenolic compounds and surfactants in the surface water of Ganga Canal, it concluded that so far phenolic compounds have not entered into surface water along the course of Ganga Canal from Pantdweep, Haridwar to Old Bridge, Roorkee. Contrary to these results, the presence of surfactants, due to bathing and washing clothes along the route of Ganga Canal, is very prominent at almost all the five sites. The concentrations of 1.18 mg/l, at site SN2 in May 2012, and of 1.63, 3.2 and 2.5 mg/l at SN3, SN4 and SN5 sites, respectively, in July 2012 were found more than permissible limit (1.00 mg/l) of BIS for surfactants. Besides at all the sites during the entire duration of studies, the values of surfactants' concentration were found more than desirable limit at all five sites during the course of monitoring. Thus, there is a need to ban the use of soap/surfactants for bathing or washing purposes to save Ganga Canal water from further pollution and to use

its water for meeting out drinking/domestic needs through surface abstraction. The studies also highlight the need of regular monitoring of the Ganga Canal water as it may pollute a large fertile agricultural land, which is irrigated through its water.

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References

- Bureau of Indian Standards (BIS) (1991) Specification for drinking water IS:10500: Bureau of Indian Standards, New Delhi
- Chauhan A, Singh S (2010) Evaluation of Ganga water for drinking purpose by water quality index at Rishikesh, Uttarakhand, India. *Rep Opin* 2(9):53–61
- Davi ML, Gnudi F (1999) Phenolic compound in surface water. *Wat Res* 33(14):3213–3219
- Deepali, Namita J (2012) Study of ground water quality in and around SIDCUL industrial area, Haridwar, Uttarakhand, India. *J Appl Tech Environ Sani* 2(2):129–134
- Eaton AD, Clesceri LS, Rice EW, Greenberg AE (2005) Standard methods for examination of water and wastewater. American Public Health Association (APHA), Washington DC
- Ettebarria N, Navarro P, Priteo A, Oilvaries M, Usobiaga A, Fernandex LA, Zuloaga O (2012) Extraction procedure for organic pollutants in determination in water. In: Schwarzbauer J, Robert D, Lichtfouse E (eds) *Environmental chemistry sustainable world*. Springer, The Netherlands, pp 171–235
- Exner M, Farber H (2006) Perfluorinated surfactants in surface and drinking water. *Environ Sci Pollut Res Int* 13(5):299–307
- Hanif NM, Adnasssn SN, Latif M, Zakaria, Abdullahand MP, Othman MR (2012) The composition of surfactants in river water and its influence to the amount of surfactants in drinking water. *World Appl Sci J* 17(8):970–975
- Kar D, Sur P, Mandal SK, Saha T, Kole RK (2008) Assessment of heavy metal pollution in surface water. *Int J Environ Sci Tech* 5(1):119–124
- Kaushik AK, Dalal JS, Panwar S (2012) Impact of industrialization on culture of Uttarakhand and its role on career enhancement VSRD. *Int J Bus Manage Res* 2(4):123–132
- Kazi TG, Arain MB, Jamali MK, Jalbani N, Afridi HI, Sarfraz RA, Baig JA, Shah AQ (2009) Assessment of water quality of polluted lake using multivariate statistical techniques: a case study. *Ecotoxicol Environ Safe* 72(20):301–309
- Kulshrestha H, Sharma S (2006) Impact of mass bathing during Ardhkumbh on water quality status on river Ganga. *J Environ Biol* 27(2):437–440
- Kumar P, Bharti PK (2012) Effluent quality assessment of different drains in SIDCUL industrial area at Haridwar (Uttarakhand). *Environ Conserv J* 13(1–2):115–118
- Lewis MA (1991) Chronic and sublethal toxicities of surfactants to aquatic animals: a review and risk assessment. *Wat Res* 25(1):101–113
- Li M, Hu C, Gao X, Xu Y, Qian X, Brown MT, Cui Y (2009) Genotoxicity of organic pollutants in source of drinking water on microalgae *Euglena gracilis*. *Ecotoxicol* 18(6):669–676
- Mishra A, Mukherjee A, Tripathi BD (2009) Seasonal and temporal variations in physico-chemical and bacteriological characteristics of River Ganga in Varanasi. *Int J Environ Res* 3(3):395–402
- Mungray AK, Kumar P (2008) Occurrence of anionic surfactants in treated sewage: risk assessment to aquatic environment. *J Hazard Mater* 160(2–3):360–370
- Murakami M, Takada M (2008) Perfluorinated surfactants (PFs) in size-fractionated street dust in Tokyo. *Chemosphere* 73:1172–1177
- Semwal N, Akolkar P (2006) Water quality assessment of sacred Himalayan Rivers of Uttaranchal. *Curr Sci* 91(4):486–496
- Shinde SG (2006) History of irrigation in India. National level conference on water management scenario 2025 problems issues and challenges. Department of History, VPM's Joshi-Bedekar College, Thane, pp 4–11

